The Economics of Shipyard Painting, III

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Maritime Administration and the U.S. Navy

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San Diego, California

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The Economics of Shipyard Painting

Phase III

Earlier Recognition of Cost Variances

15 October 1990

U.S. Department of Transportation

Maritime Administration

Prepared by:

Insight Industries, Inc.
Plattville, Wisconsin

For:
Peterson Builders, Inc.
Sturgeon Bay, WI 54235-0047

In Cooperation with:

NASSCO
National Steel and Shipbuilding Company
San Diego, California

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FORWARD

This research project is being performed under the National Shipbuilding Research Program, specifically under the guidance of Panel SP-3, Surface Preparation and Coating, of the Ship Production Committee of SNAME. The report covers the third phase and final phase of an effort that examines the economics of shipyard painting. The purpose of the third phase is to develop a system for the Paint Department which provides timely information concerning potential cost overruns to shop supervision.

Mr. Gary Higgins of Peterson Builders, Inc. (PBI), and Mr. Steven Garlick of Insight Industries, Inc., served as project Manager and Principal Investigator, respectively.

We appreciate the support that the Maritime Administration has given toward this project. We also wish to express special thanks to the private and U.S. Naval shipyards that provided critical feedback concerning our project approach. Appendix A provides a listing of the companies and individuals who contributed to the development of this project.

THE ECONOMICS OF SHIPYARD PAINTING (PHASE III)

EXECUTIVE SUMMARY

Typically, Paint Shop supervision does not have the management tools available to compare shop performance to the budget until nearly the end of a contract. The lack of information required for recognizing causes of low productivity, results in cost overruns that cannot be explained. The purpose of this study was to develop a system for a Paint Department which could provide shop supervision with timely information concerning cost performance.

Three areas were investigated in Phase III: Lost Time, Abnormal Conditions, and Hotwork Identification. Lost Time occurs when a worker is physically ready to perform the work defined by the work order, but must wait for some event to occur before work can be started. Abnormal conditions are those factors which hamper productivity and drive costs. Hotwork Identification was found to be important in quantifying the amount of rework resulting from hotwork not completed before blast and paint.

The research effort documented in this report, combined with efforts of Phase I and Phase II, shows the importance of a labor database which is capable of much more than simply fulfilling accounting requirements. Phase I showed how detailed labor information could be used to perform shop methods improvements; Phase II showed that the same system could supply bid estimating data; and Phase III shows that the labor system can be used to identify cost variances at an early stage.

Essential to realizing such benefits from a labor system is the need for thorough planning in determining the data elements that need to be collected. The addition of carefully planned labor attributes to an existing labor collection system can result in a valuable management tool for shop supervision.

Table of Contents

1.0 INTRODUCTION 1

2.0 PRODUCTIVITY MEASUREMENT METHODS 3
2.1 Job Progress/Cost 3
2.2 Material Usage/Cost 4

3.0 PAINT SHOP EMPLOYEE WORK CODES 5
3.1 Manpower Reporting 6
3.2 Lost Time 7
3.3 Abnormal Condition 9
3.4 Reports Formed from Resulting Data 11
3.4.1 Paint Department Total Hours per Compartment by Work Order and Operation 11
3.4.2 Paint Department Rework Hours per Compartment by Work Order and Operation 12
3.4.3 Paint Department Lost Time Hours per Compartment by Work Order and Operation 12
3.4.4 Irregular Time Summary Report by Compartment Number 12
3.4.5 Abnormal Condition Detail Report 12
3.4.6 Percent Completion Report 13
3.5 Conclusions and Benefits from Additional Work Code Data 13

4.0 HOTWORK IDENTIFICATION 15
4.1 Trial Run for Hotwork Identification 15
4.2 Future Plans for Eliminating Hotwork 15

5.0 THREE YEAR CONCLUSION 17

1.0 INTRODUCTION

Phase I of "The Economics of Shipyard Painting" discussed the costs of painting a vessel. The report explained in detail both the direct and indirect costs shipyards typically experience during the coating process. The study emphasized the importance of not overlooking the cost drivers. Too often the expense of painting is thought to be only the cost of paint and the application time involved. In Phase I, it was found that only 16% of the Paint Department's manhours resulted from the direct application of paint.

During Phase I, an attempt was made to categorize the remaining 84% of labor expended by the Paint Department. Several data fields were added to the labor cards, including compartment numbers, operation codes, rework codes, and material type and quantity used. That alteration of the existing labor collection system provided data that could be used to support shop supervision, as well as accounting. The shop supervisor was now enabled to see the amount of time spent on specific tasks, the material types and quantities used, as well as the specific causes of rework.

Phase II of "The Economics of Shipyard Painting" made use of the same data to automate the bid-stage estimating process. The success of this program was dependent on the quality of the historical data. As expected, more variance was encountered with data from older contracts. Unexpectedly, the newer contracts were also displaying variances which distorted the bid stage estimates. The issue of understanding those variances was studied in Phase III.

The objective of Phase III of "The Economics of Shipyard Painting" was to develop a system for the Paint Department which would provide shop supervision with timely information concerning cost overruns. In many cases, shop supervision had very little knowledge concerning work order performance, especially on broadly-scoped work orders covering a long time span. The need existed for accurate information of unfavorable cost performance at an earlier stage of production. This information was needed not only to explain cost overruns, but to facilitate midstream corrections.

2.0 PRODUCTIVITY MEASUREMENT METHODS

Initially it was thought that three job progress reports would be developed in the course of this study. The first job progress report would capture the total labor cost, including the additional cost for overtime, dirty pay, etc. The second job progress report would capture material usage data. The final job progress report would summarize labor and material cost to determine total job cost. In order to achieve the total job cost objective, both labor and material usage had to be measured using the same units. The only unit of measurement common to both appeared to be dollars.

In order to test the soundness of reporting budget variances in the form of dollars, a survey was sent to PBI Paint Shop supervision and also to various Paint Shop persomel from other shipyards. See Appendix B. In addition, telephone interviews were conducted with several yards. See Appendix C. Based on the information obtained from the survey and the telephone interviews, some research areas were eliminated and other areas were added. Those areas are discussed in the following sections.

2.1 Job Progress/Cost

Though a logical case can be made for measuring labor costs in dollars, such measurement is precluded by current accounting procedures which burden labor costs with overhead expenditures. It has become standard practice in shipyards to measure labor costs strictly in terms of manhours. Therefore, the additional costs of overtime and dirty pay could not be analyzed in this study.

2.2 Material Usage/Cost

Tracking material usage and cost would seem to have several benefits:

1. The use of more expensive material could be justified if seen to be offset by a lower application cost.
2. Paint consumption at a different rate than expected could indicate improper film thickness.
3. Early recognition of material overruns could alert the shipyard to order additional material, preventing interruption of the work schedule.
4. The accuracy of material estimates could be verified.

Shipyards, however, regard the material cost of their painting operations to be far less significant than labor costs. Therefore, this study did not investigate material usage. It should be noted, however, that the collection of material usage data will become mandatory as other states adopt marine coating regulations similar to those in California.

3.0 PAINT SHOP EMPLOYEE WORK CODES

As stated in the Introduction, the Paint Shop Time Card was changed during Phase I. Several Operation Codes were added to the cards for better tracking of manhour expenditure:

CK = Caulk Butts and Seams	PS = Spray Paint
CL = Clean	SB = Sand Blast
CA = Cleanup Abrasive	SD = Sand
DC = Apply Deck Covering	ST = Stenciling
FH = Fill Holes	TP = Tape
EP = Setup/Tear Down Equipment	UT = Untape
GR = Grind	ZS = Zip Strip
PB = Brush Paint	OR = Other

Rework was tracked by the addition of the following codes:

TR = Trades	IA = Improper Application
PS = Painted Out of Sequence	PM = Poor Quality Material
WT = Weather	FE = Faulty Equipment
IP = Improper Preparation	

The reason for adding the above codes to the time cards was to help explain some of the variance that occurs in the Paint Shop labor database. The intent was to add more credibility to the data and make it more useful for the Bid Stage Estimating Program developed in Phase II of "The Economics of Shipbuilding".

3.1 Manpower Reporting

During Phase I, the category of rework was added to the Paint Shop Time Card for identifying costs adding variance to an estimate, but variances still occurred. It was evident that hidden factors were driving the variability of the data, because the actual hours versus the estimated hours were so mismatched. Variances in historical data had produced poor estimates with some work being overestimated and some work being underestimated.

Poor quality estimating procedures and inaccurate work estimates present a real problem to shop supervisors who are held accountable to perform to such estimates. The resulting inclination to mischarge time is clearly defined by Storch, Hammon and Bunch:

> "This work then becomes a prime candidate for 'creative progress reporting' by various shops. . . Shop foremen simply charge resources expended for one job to the job with the remaining budget. It is something like a pyramid club. The final accounting can be deferred as long as some work orders are still open. The shop foremen, of course, hope to bring budgets into line through various efficiencies before the final accounting. Even if this is done, it is impossible to properly account for expended costs of some sections of the ship. As a result, estimating

> future jobs or even ships in the same series is very inexact. Additionally, areas where productivity might be improved may be disguised. Management doesn't know that such areas are contributing to costs in excess of what was planned. Consequently, no effort may be made to correct the situation."

The inaccuracies created by the mischarging may indeed be a major reason why many bid estimating procedures are unsuccessful. Even though it should be no surprise that the accuracy of bid estimating is primarily dependent on the accuracy of historical data, discussions with other shipyards confirmed that mischarging and "creative progress reporting" seem to be a common problem. The best hope of improving the quality of time charging and labor estimating appears to be in the establishment of detailed work breakdown structure and detailed time-charging codes.

3.2 Lost Time

A primary concern in improving the quality of time charging is the category of Lost Time. Lost Time is recorded only when a worker must wait for some event beyond his/her control before beginning or resuming the assigned task. Several specific examples of Lost Time are:

- Waiting for supervisory instruction
- Waiting for additional material
- Waiting for another task to be completed
- Waiting for a weather-related work delay

The definition of Lost Time is amplified by Storch, Hammon and Bunch:

> " [One] source of low productivity is idleness. A major source of idleness is a breakdown in resource scheduling and control. Workers report to a job and find someone from another trade in their way because of a lack of schedule coordination. The workers wait. Workers need some part to complete a task. One goes to find the part. The rest wait. Drawings are not available as needed or a change to the drawings is incomplete. The workers wait. A critical previous task is not completed, or some owner provided equipment does not arrive on time. The workers wait. The list goes on and on."

Pinpointing the reasons for Lost Time is important because it provides shop supervision with an explanation of why unproductive the occurs. Perhaps more importantly, it provides shipyard management with valuable information regarding opportunities for continuous improvement of methods and processes.

When Lost Time occurs an "LT" is entered in the "Operation Code" column of the Paint Shop Time Card. (See Appendix D for the revised Paint Shop Time Card.) An additional column entitled "Lost Time Code" was added to the time card. The Lost Time codes shown below are entered in the additional column:

AI = Additional Instructions
AM = Additional Materials
EM = Equipment Malfunction
ER = Equipment Being Repaired

TR = Trade Interference
WT = Weather -- Explain
OR = Other (must have a corresponding comment)

The responsibility for reporting and analyzing Lost Time has been divided between Paint Shop personnel. The Paint Shop foreman has the responsibility for properly educating Paint Shop employees, tracking of data, and analyzing the data collected as a result of the Lost Time reports. The foreman also has the responsibility for recommending improvements to the system. The leadmen are responsible for verifying that Lost Time descriptions exist when LT is selected as an Operation Code. A LT description is forced when LT is selected as an Operation Code during data entry. The Paint Shop employees continue to be responsible for accurately recording all required data on the Paint Shop Time Cards.

3.3 Abnormal Condition

The second area of major concern when identifying variances is Abnormal Conditions. Abnormal Conditions refer to those factors which hamper productivity and drive costs. Such conditions include tasks which normally are not the responsibility of Paint Shop employees:

- Having to work around or remove items left by other trades
- Tasks not properly completed by other trades
- Components installed in poor sequence
- Countermeasures to offset adverse environmental conditions
- Rescheduling of work after setup has started

When an Abnormal Condition occurs, the Paint Shop employee makes note of it in the last column of the Paint Shop The Card. See Appendix D. The codes shown below specify reasons for the extra time that has occurred:

DI = Dirty Area
EL = Equipment Left Behind
ER = Equipment Removed
FE = Faulty Equipment
PM = Poor Quality Material
PS = Painted Out of Sequence
TR = Trade Interference
WR = Work Rescheduled
WT = Weather

If difficulty is encountered in distinguishing Rework from Abnormal Conditions, the following explanations have proven helpful:

Rework - extra hours doing work that has already been completed at least once before, but needs to be redone.

Abnormal Condition - extra hours doing work that is being done for the first time, but requires additional time due to out-of-the-ordinary circumstances.

The responsibilities for reporting and analyzing Abnormal Condition data are as follows:

Paint Shop Foreman

1. Educating Paint Shop employees
2. Analyzing data resulting from Abnormal Condition reports
3. Recommending system improvements

Paint Shop Leadman

1. Identifying and recording Abnormal Conditions
2. Projecting the amount of time to overcome Abnormal Conditions
3. Calculating the actual amount of time caused by the Abnormal Condition

3.4 Reports Formed from Resulting Data

Many of the existing reports generated by the mainframe at PBI were changed to reflect the additional data collected from the time cards. Several new reports were developed. See Appendix F. The first page of Appendix F contains a list of descriptions for all work codes used at PBI. Each of the reports are discussed below.

3.4.1 Paint Department Total Hours per Compartment by Work Order and Operation

This report (Appendix F-1) was revised from Phase I to include Lost Time. The report's purpose is to give the Paint Shop foreman a listing of all production data recorded by the workers and how much time was spent on each operation and compartment.

3.4.2 Paint Department Rework Hours per Compartment by Work Order and Operation

This report (Appendix F-2) was not revised from Phase I. Its purpose is to inform the foreman of what areas are causing the most Rework on a specified contract.

3.4.3 Paint Department Lost Time Hours per Compartment by Work Order and Operation

This report (Appendix F-3) was created as a result of Phase III. The purpose of this report is to inform the foreman of what areas are causing the most Lost Time on a specified contract.

3.4.4 Irregular Time Summary Report by Compartment Number

This report (Appendix F-4) was created as a result of Phase III. A similar report was also created listing the information by Work Order. The purpose of this report is to inform the foreman of how many hours the Paint Shop spent (on a compartment basis) completing each of the regular work items, each type of Rework, under-productive work due to Abnormal Conditions, and waiting due to Lost Time. The total number of irregular hours, regular hours, and the percent of irregular hours are listed for each compartment. The end of this report lists the hull totals.

3.4.5 Abnormal Condition Detail Report

This report (Appendix F-5) lists all Abnormal Condition codes occurring on a specified contract, along with the corresponding date, the number of extra hours, the leadman’s

clock number, the work order number, and a comment giving additional details. (The leadmen were asked to include a comment whenever possible.)

3.4.6 Percent Completion Report

This report provides shipyard supervision and management a realistic estimate of remaining work. See Appendix F-6. The report has proven to be very beneficial to the Paint Department. The first two columns state the work order number and description. The third column states the budget hours for each work order. The fourth column provides the foreman's estimate of physical completion. The fifth through eighth columns list the Rework, Lost Time, Regular, and the Year to Date Hours. Abnormal Condition data is not included because it is not entered into the mainframe.

The ninth through eleventh columns list the hours remaining to the current estimate, the percent complete with respect to the original estimate, and the percent complete with respect to the current estimate. The purpose of this information is to show where the project is in relation to not only to the original estimate, but to the currently revised estimate. The very last column, titled "Percent Complete WRT Physical Progress", is marked with the word "CLOSED" when the Paint Shop officially closes the corresponding **work order.**

3.5 **Conclusions and Benefits from Additional Work Code Data**

It was discovered that productivity of the second and third shifts was noticeably less than that of the first shift because not as many support people were available for tasks such as cleaning, repairing, and material handling.

Paint Shop employees had become more aware of time usage. They were able to identify additional costs in shipbuilding which had not been given enough consideration during the bidding and planning stage. For instance, a vessel was being built at a PBI facility located several miles away from the main facility. All travel time was recorded as Abnormal Conditions. The extra time required for travel was not taken into consideration during the bidding process. Because the Paint Shop had records of this extra time, they were able to justify and receive additional resources.

Perhaps the most important aspect of clearly defining manhour expenditure through detailed cost collection is the increased potential to bid with accuracy and confidence.

4.0 HOTWORK IDENTIFICATION

The final area of investigation was prevention of rework caused by hotwork being performed after completion of blasting and painting. During Phase I of "The Economics of Shipyard Painting", it was determined that 80% of all rework appeared to be in the areas of studs, foundations, and pipe penetrations.

4.1 Trial Run for Hotwork Identification

Several avenues were investigated for the best way of identifying the hotwork items and who would be responsible for assuring they were installed. During a trial run, all hotwork items were identified on the CNC Cutting Machine drawings for the first hull in a series of small vessels. The hotwork items could be tabulated on a checklist or on the drawings. The data collected from Hull 1 was entered into a spreadsheet, and then sorted by panel, distance off centerline, distance off deck, and distance off frame, respectively.

The spreadsheet was then used on Hull 2 just before the blast and paint date to see if all the hotwork was complete. Information regarding hotwork items was reported to the Paint Shop foreman. The data regarding missing items for two panels is shown in Appendix G.

4.2 Future Plans for Eliminating Hotwork

The structure of the existing work order breakdown was by department and system. It is proposed the work orders will

be separated by panel, with several departments charging to the same work order. Work will be more clearly identified and planned in greater detail. The location of all penetrations and attachments to the panels will be specified on ship drawings allowing installation prior to ship assembly. Panel edges will be taped allowing blast and prime at the panel stage. After all systems are installed, final paint will occur.

By adding attachments at the panel stage, the amount of down-hand work can be increased. Another benefit resulting from the additional planning is that the number and type of attachments will be identified, allowing for batch production of similar parts. These components will have different part numbers based on their stage of construction. In the end, an environment will exist for the computerized tracking of materials.

5.0 THREE YEAR CONCLUSION

In reviewing the three phases of "The Economics of Shipyard Painting", perhaps the best summary of the total effort can be found in the Executive Summary of Phase I.

"The shipbuilding industry has a complex environment. History has proven that the amount of labor involved in constructing a ship can be difficult to predict. Some say that the mass production operation found in high volume manufacturing has little in common with the job shop found in shipbuilding, and that traditional Industrial Engineering techniques are therefore unsuitable for treating problems in shipyards. The basic question is whether an end product cost associated with a complex component in a ship can actually be predicted.

Studies at several U.S. shipyards under the National Shipbuilding Research Program suggest that it is, indeed, possible to produce effective estimates of work content, worker performance, and cost in the shipyard environment, and to use this information toward control of actual costs. Pipe Fabrication, Sheet Metal, and Electrical shops have been the target of these studies, and have shown successful results. There remains one area that has continued to defy estimating, however, and that area is Painting. The painting operation is somewhat unique among shipyard trades in that the end product of the Paint Department is extremely susceptible to damage by other trades. The resulting rework costs are generally quite high. Rework costs are usually folded into the total painting cost, without separate identity. The high total painting costs, therefore, may suggest that the basic painting took more hours than were originally scheduled,

whereas the true reason for the high cost was rework caused by other trades. Separate identity and tracking of the cost drivers in the painting area are essential to resolving the problems that are truly responsible for high painting cost.

There is an added incentive for increasing the productivity of the painting operation with respect to rework, and this is associated with the critical role of the Paint Department in the zone outfitting concept. In fact, of all the shipyard trades, the Paint Department assumes the most important role as an identifier of zone outfitting problems, which manifest themselves as painting rework and touchup late in the construction cycle."

"The Economics of Shipyard Painting" has identified the individual painting operations and their associated costs. It has produced statistically-based estimating factors and it has established a system for defining the quantity and causes of cost variances. The research has not produced an easy shortcut or panacea to guarantee cost-effective painting operations in a shipyard. It has, however, dealt directly with the issues and factors that work to prevent cost-effective painting operations in a shipyard.

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APPENDICES

Table of Contents

Appendix A: Acknowledgements and Sources of Information
Appendix B: Survey
Appendix C: Survey Results
Appendix D: Paint Shop Time Card
Appendix E: Paint Shop Abnormal Condition Card
Appendix F: Revised Paint Shop Reports
Appendix F-1
Appendix F-2
Appendix F-3
Appendix F-4
Appendix F-5
Appendix F-6
Appendix G: Hotwork Checklist for a Small Vessel

Appendix A

Acknowledgements and Sources of Information

The following companies provided information on existing resource tracking systems and what problems areas they are currently experiencing:

* Sparrows Point Shipyard
* Ingalls Shipbuilding
* Bath Iron Works
* National Steel and Shipbuilding Company
* Puget sound Naval Shipyards

Appendix B

MarAd SP-3 Panel

Surface Preparation and Coatings

Phase III, The Economics of Shipyard Painting

This survey asks for your input regarding the various activities that affect the Paint Department. This survey is part of the third year of the research project The Economics of Shipyard Painting. The purpose of this project is to provide the paint-shop with detailed information that can help identify problem areas much earlier in the construction cycle and thus allow corrective action to be taken in a timely manner. We would appreciate it if you would take a few minutes of your time and complete the questions below.

What activities of non-production departments (Purchasing, Engineering, Planning, etc) significantly influence cost overages in the Paint Department?

What activities of production departments (Pipe Shop, Fitters, Electrical Shop, etc) significantly influence cost overages in the Paint Department?

What activities internal to the Paint Department significantly influence cost overages?

What benefits can be expected with timely knowledge of cost overage data:

With respect to labor hours?

With respect to material usage?

What can be done in the Paint Department to avoid paying premium hourly rates for weekends, holidays, overtime, etc?

What misleading conclusions can be formulated about the Paint Department's productivity when referring only to labor returns versus total costs?

In what format should cost overage data be submitted to upper management in order to stimulate effective decisions that will improve productivity in the Paint Department?

Title/Position Held: _____

Appendix C

Survey Results

The following is a listing of the survey results from the Surface Preparation and Coatings Survey.

What activities of non-production departments (Purchasing, Engineering, Planning, etc) significantly influence cost overages in the Paint Department?

A) The lack of a schedule--in almost every project that the paint shop is involved in, there is unpredicted rework that draws up the cost . The schedule, or lack of it, always places an increased pressure at the conclusion of a project.

B) No schedules or schedules that are never met and are changed. Late E.C.N.'s (Engineer Change Numbers) or drawings that are not given to other trades in time to get their work completed before painting. Needless painting for launches requested by upper management.

C) Planning affects the Paint Department the most because if a job is done out of sequence, which does happen, it costs more to do the job after the wrong trade was in performing their work, because it makes our job harder and more frustrating than it has to be.

D) Poor planning and\or scheduling causes much rework--items purchased or received late by other departments causes rework.

E) Purchasing -- paints and coatings may be less expensive per gallon, but very difficult to work with, causing labor hours to more than offset cheaper purchase price.
Engineering--changes in system after paint out of compartment, i.e., pipe, lighting and ventilation.
Planning-- entire sequence of work, especially outfitting has to be planned so that a very maximum of all items be installed prior to paint out.
Estimating--sometimes overages are blamed on Paint Department, when it is really due to low estimates.

What activities of production departments (Pipe Shop, Fitters, Electrical shop, etc) significantly influence cost overages in the Paint Department?

A) Because there is no schedule of construction, the other production trades almost invariably cause a crunch at the conclusion of a project. This crunch generally causes a time scramble and overtime in the Paint Department.

B) Foundations, pipes, pipe hangers, electric wires, etc. , that are added after final paint out. Also, testing that is not completed before paint out so we have to tape off pipe joints or zip strip joints that got painted and weren't tested yet.

C) All trades affect cost overages because it always happens when you finish out a room, another trade comes in and adds something they forgot, or there is an engineering change, or the job is not planned correctly.

D) Adding or reworking items after paint, such as hot work, new wires, etc. ; testing not completed before painting.

E) Pipe shop, fitters, electrical shop, etc. All other crafts have to be as complete as possible prior to paint out in order to eliminate as much rework as possible, i.e., improper alignment of foundations, incomplete welding, cable runs not banded, pipes not tested, etc.

What activities internal to the Paint Department significantly influence cost overages?

A) Improper application of coatings, be it wrong color, improper finish or improper thickness. Problems with equipment, be it sandblasters, spray units or compressors.

B) Poor bidding and poor paint application causing rework. Lack of equipment such as another compressor for blasting.

C) Weather; Equipment Problems; Too Heavy Paint Application, or Not Enough; Bad Information--such as MIL's Required listed on Spec Sheet; Improper Facilities for Certain Paint Processes.

D) Low bids; equipment not suited for certain jobs--worn out air compressor, giraffes that are continually broke down. Not having a quality spray booth for finish work.

E) Improper Surface preparation, improper paint application, over spray on equipment and parts that are required to remain free of paint. Improper MIL thickness, use of wrong material, poor planning, lack of training and lack of production.

What benefits can be expected with timely knowledge of cost overage data:

With respect to labor hours?

A) The early knowledge of cost overage will allow the paint department to determine if the bid was faulty, the schedule incorrect, or the performance of the shop causing the overage.

B) If cost overage is red-flagged soon enough, something could possibly be done at that time to get it back on track. It could

also be used on future contracts to high-lite problem areas and possibly help prevent the same problems.

C) Lower Labor Hours: Properly Prepared Material--such as Pre-primed Steel; Better Scheduling.

D) Alternate planning and scheduling can be done early to make up time. Not always leaving it up to the paint department to work the overtime in the end.

E) Early knowledge of cost over runs permit those involved to examine the job and try to determine the cause and make necessary adjustments and changes.

With respect to material usage?

A) With the early recognition of material overage, the additional material could be purchased to allow the project to continue without interruption.

B) It should help control the excessive use of paint caused by rework.

C) Should use proper amount of material for a job; cut down on man hours; cut down an paint waste.

D) This would key workers on any material being applied to the wrong milage, etc. It would make it possible to reorder material needed and get it in time and possibly keep the company from having to use air freight costs. It could hep you with your next bid work.

E) Allows investigation for waste, validity of original material estimates but also prevents hold up of job due to lack of material.

What can be done in the Paint Department to avoid paying premium hourly rates for weekends? holidays, overtime, etc?

A) Better planning and scheduling of work.

B) I don’t think much can be done in the Paint Department to avoid overtime. What needs to be done is a proper schedule set up and met by the other trades, so they can get their work completed in time and allow us sufficient our job on schedule.

C) Proper Planning-- schedules that can be counted on, not changed weekly.

D) Develop a schedule for all work (all trades) and stick to it. Don’t let early work slip and expect the last departments to work all the overtime to keep the work on schedule.

E) History shows that the Paint Department is at the mercy of planners, other crafts, and top management decisions which influence overtime hours. Various jobs have to be accomplished on an off shift basis such as blast/paint bilges, to prevent interference with other crafts. Sometimes overly optimistic schedules force the Paint Department to go to overtime hours in order to meet milestone dates.

What misleading conclusions can be formulated about the Paint Department's productivity when referring only to labor returns versus total costs?

A) At certain times overtime can be justified. People with some skills can save on the total cost because of their ability, even though they may receive for their work.

B) If you look at labor returns only, it doesn't show much extra time and material was used for doing things over due to improper scheduling or improper sequencing during construction. It costs a lot more to do things the second time, both in dollars and in morale of the workers.

C) I don't think the rework factor is given as much attention as it should get. I think total man hours are just looked at.

D) Labor returns don't always reflect the rework the Paint Department does that is caused by other trades. Weather can also have an effect. Poor schedules.

E) Labor returns are a direct reflection of productivity as hours are accumulated verses budget. All other costs accumulated on a given job have to be analyzed on their own merit.

In what format should cost overage data be submitted to upper management in order to stimulate effective decisions that will improve productivity in the Paint Department?

A) The format that upper management receives should be up to date and take into consideration the hours charged to all work orders, not just the work orders that are closed.

B) I think it should be given in both a written and oral presentation showing what causes the overages and what could be done to prevent them.

C) Format showing all info, including the following: rework, material lost due to rework, time lost due to rework. The Full Picture of the cost data.

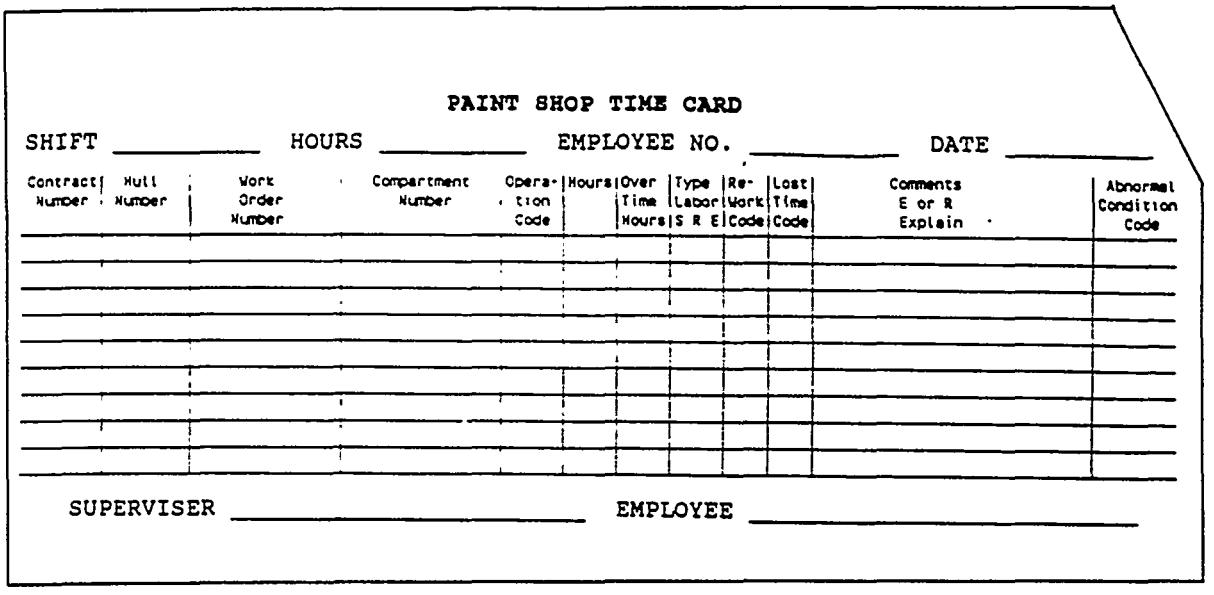
D) In process data should be recorded during a contract showing the reasons for rework as it happens. Also, on equipment breakdowns,

inadequate equipment, weather problems, etc. This information could be submitted with cost overage data. Photos of damaged areas that cause rework may help also.

E) Submitted by cost account breakdown with reasons, if known, for each.

Appendix D

Paint Shop Time Card

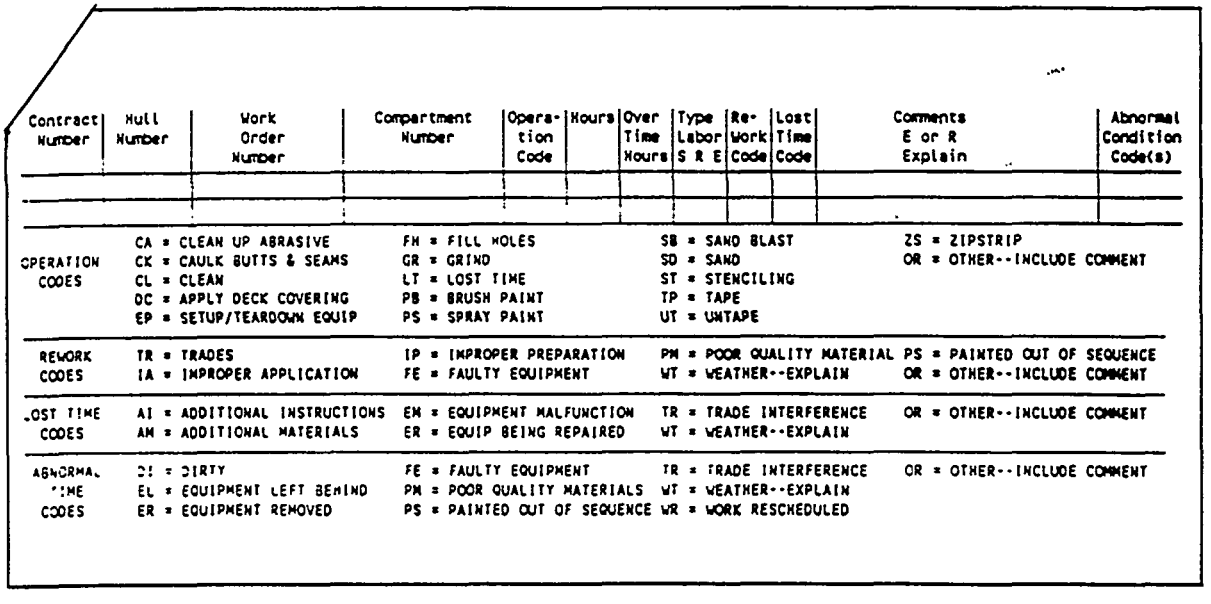


PAINT SHOP TIME CARD

SHIFT _____ HOURS _____ EMPLOYEE NO. _____ DATE _____

Contract Number	Hull Number	Work Order Number	Compartment Number	Operation Code	Hours	Over Time Hours	Type Labor S R E	Re-Work Code	Lost Time Code	Comments E or R Explain	Abnormal Condition Code

SUPERVISER _____ EMPLOYEE _____

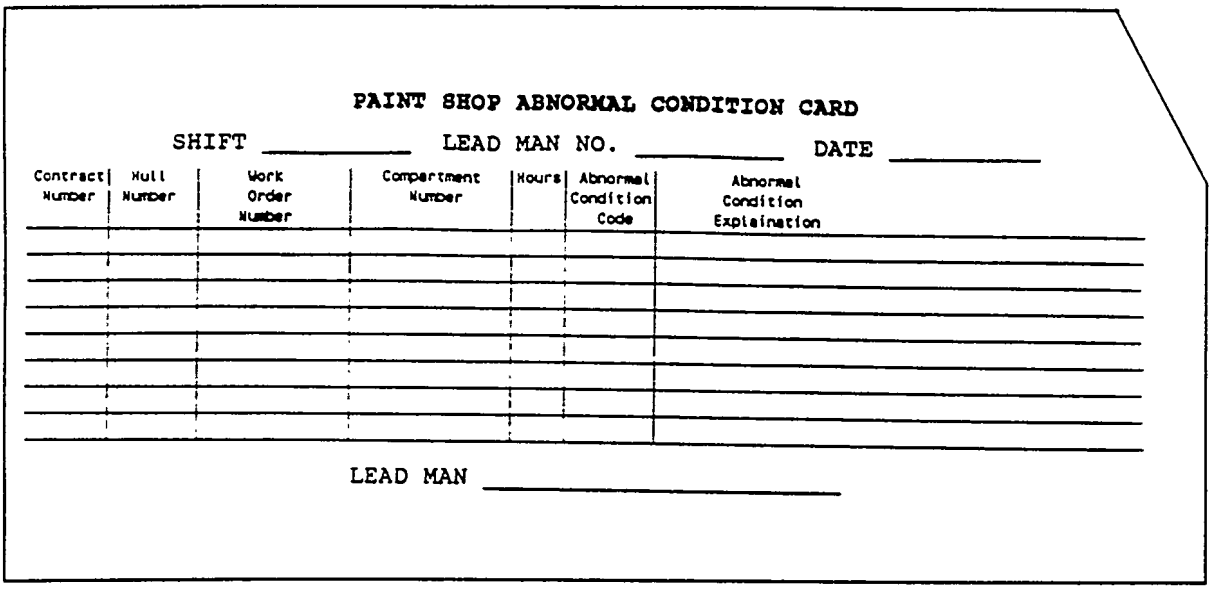


Contract Number	Hull Number	Work Order Number	Compartment Number	Operation Code	Hours	Over Time Hours	Type Labor S R E	Re-Work Code	Lost Time Code	Comments E or R Explain	Abnormal Condition Code(s)

OPERATION CODES	CA = CLEAN UP ABRASIVE CK = CAULK BUTTS & SEAMS CL = CLEAN DC = APPLY DECK COVERING EP = SETUP/TEARDOWN EQUIP	FH = FILL HOLES GR = GRIND LT = LOST TIME PB = BRUSH PAINT PS = SPRAY PAINT	SB = SAND BLAST SD = SAND ST = STENCILING TP = TAPE UT = UNTAPE	ZS = ZIPSTRIP OR = OTHER--INCLUDE COMMENT	
REWORK CODES	TR = TRADES IA = IMPROPER APPLICATION	IP = IMPROPER PREPARATION FE = FAULTY EQUIPMENT	PM = POOR QUALITY MATERIAL WT = WEATHER--EXPLAIN	PS = PAINTED OUT OF SEQUENCE OR = OTHER--INCLUDE COMMENT	
LOST TIME CODES	AI = ADDITIONAL INSTRUCTIONS AM = ADDITIONAL MATERIALS	EM = EQUIPMENT MALFUNCTION ER = EQUIP BEING REPAIRED	TR = TRADE INTERFERENCE WT = WEATHER--EXPLAIN	OR = OTHER--INCLUDE COMMENT	
ABNORMAL TIME CODES	DI = DIRTY EL = EQUIPMENT LEFT BEHIND ER = EQUIPMENT REMOVED	FE = FAULTY EQUIPMENT PM = POOR QUALITY MATERIALS PS = PAINTED OUT OF SEQUENCE	TR = TRADE INTERFERENCE WT = WEATHER--EXPLAIN WR = WORK RESCHEDULED	OR = OTHER--INCLUDE COMMENT	

Appendix E

Paint Shop Abnormal Condition Card

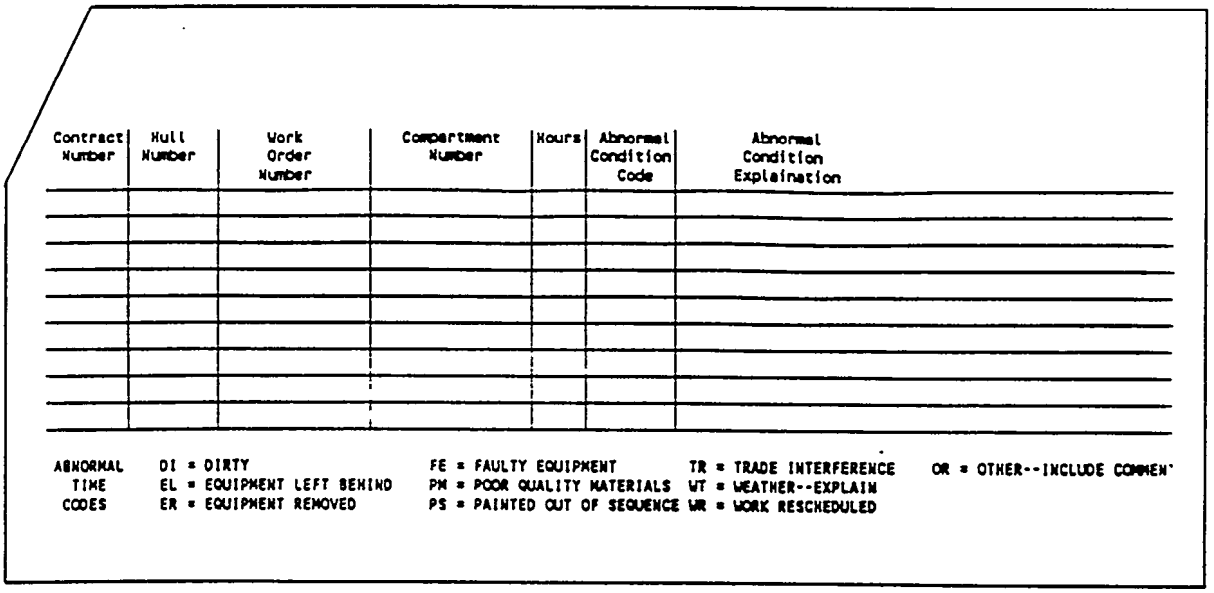


PAINT SHOP ABNORMAL CONDITION CARD

SHIFT _____ LEAD MAN NO. _____ DATE _____

Contract Number	Hull Number	Work Order Number	Compartment Number	Hours	Abnormal Condition Code	Abnormal Condition Explaination

LEAD MAN _____



Contract Number	Hull Number	Work Order Number	Compartment Number	Hours	Abnormal Condition Code	Abnormal Condition Explaination

ABNORMAL TIME CODES

DI = DIRTY
EL = EQUIPMENT LEFT BEHIND
ER = EQUIPMENT REMOVED
FE = FAULTY EQUIPMENT
PM = POOR QUALITY MATERIALS
PS = PAINTED OUT OF SEQUENCE
TR = TRADE INTERFERENCE
WT = WEATHER--EXPLAIN
WR = WORK RESCHEDULED
OR = OTHER--INCLUDE COMMEN

Appendix F-1

Paint Department Total Hours per Compartment by Work Order and Operation

CONTRACT #
HULL #
ZONE #
COMPARTMENT #

PAINT DEPARTMENT TOTAL HOURS PER COMPARTMENT BY WORK ORDER AND OPERATION

(NOTE: HOURS ON THIS REPORT ARE ROUNDED TO THE NEAREST HOUR)

WORK ORDER TOTALS

W.O.#	CA	CK	CL	DC	EP	FH	GR	LT	OR	PB	PS	SB	SD	ST	TP	UT	ZS	RW	TOTAL
									7			1							8

WORK ORDER TOTALS

W.O.#	CA	CK	CL	DC	EP	FH	GR	LT	OR	PB	PS	SB	SD	ST	TP	UT	ZS	RW	TOTAL
	2	7	58		13	4	1	2	74	72	119	45	91		78	17			583

COMPARTMENT TOTALS

CA	CK	CL	DC	EP	FH	GR	LT	OR	PB	PS	SB	SD	ST	TP	UT	ZS	RW	TOTAL
2	7	58		13	4	1	2	81	72	119	46	91		78	17			591

ZONE TOTALS

CA	CK	CL	DC	EP	FH	GR	LT	OR	PB	PS	SB	SD	ST	TP	UT	ZS	RW	TOTAL
2	7	58		13	4	1	2	81	72	119	46	91		78	17			591

HULL TOTALS

CA	CK	CL	DC	EP	FH	GR	LT	OR	PB	PS	SB	SD	ST	TP	UT	ZS	RW	TOTAL
2	7	58		13	4	1	2	81	72	119	46	91		78	17			591

WORK ORDERS USED ON THIS HULL

TOTAL HOURS - 8.00
TOTAL HOURS - 542.00

CONTRACT TOTALS

CA	CK	CL	DC	EP	FH	GR	LT	OR	PB	PS	SB	SD	ST	TP	UT	ZS	RW	TOTAL
2	7	58		13	4	1	2	81	72	119	46	91		78	17			591

Appendix F-2

Paint Department Rework Hours per Compartment by Work Order and Operation.

CONTRACT #
HULL #
ZONE #
COMPARTMENT #

PAINT DEPARTMENT REWORK HOURS PER COMPARTMENT BY WORK ORDER AND OPERATION

WORK ORDER 631-001 TOTALS

OPERATION	FE	IA	IP	MR	OR	PM	PS	TR	WT	TOTAL
CL								6.50		6.50
PB								4.50		4.50
W.O. TOTAL								11.00		11.00

COMPARTMENT TOTALS

FE	IA	IP	MR	OR	PM	PS	TR	WT	TOTAL
							11.00		11.00

ZONE TOTALS

FE	IA	IP	MR	OR	PM	PS	TR	WT	TOTAL
							11.00		11.00

HULL TOTALS

FE	IA	IP	MR	OR	PM	PS	TR	WT	TOTAL
				14.00			16.50		30.50

WORK ORDERS USED ON THIS HULL

9733 0001 631-001 TOTAL REWORK HOURS - 30.50

Appendix F-3

Paint Department Lost Time Hours per Compartment by Work Order and Operation

CONTRACT #
HULL #
ZONE #
COMPARTMENT #

PAINT DEPARTMENT LOST TIME HOURS PER COMPARTMENT BY WORK ORDER AND OPERATION

WORK ORDER 630-001 TOTALS

OPERATION / LT	AI	AM	EM	ER	OR	TR	WT	TOTAL
W.O. TOTAL					1.00			1.00
					1.00			1.00

COMPARTMENT TOTALS

AI	AM	EM	ER	OR	TR	WT	TOTAL
				1.00			1.00

ZONE TOTALS

AI	AM	EM	ER	OR	TR	WT	TOTAL
				1.00			1.00

HULL TOTALS

AI	AM	EM	ER	OR	TR	WT	TOTAL
				1.00			1.00

WORK ORDERS USED ON THIS HULL

TOTAL LOST TIME HOURS - 1.00

CONTRACT TOTALS

AI	AM	EM	ER	OR	TR	WT	TOTAL
				1.00			1.00

Appendix F-4

Paint Department Irregular Time Summary Report by Compartment Number

IRREGULAR TIME SUMMARY REPORT BY WORK ORDER NUMBER
CONTRACT #:
HULL #:
WORK ORDER #:
WORK ORDER DESCRIPTION: PREP AND PAINT BOAT

LOST TIME			REWORK			ABNORMAL CONDITION			REGULAR HOURS		
CODES	OCCURANCES	HOURS	CODES	OCCURANCES	HOURS	CODES	OCCURANCES	HOURS	CODES	OCCURANCES	HOURS
AI			FE			DI			CA	1	2.00
AM			IA			EL			CK	4	6.25
EM			IP			ER			CL	44	50.00
ER			PM			FE	1	1.50	DC		
TR			PS			PM			EP	7	11.00
WT			TR			PS			FH	3	3.50
OR	2	1.00	WT			TR	2	1.50	GR	1	.50
			OR			WT	1	4.00	PB	21	69.00
						WR			PS	45	112.25
						OR	18	49.00	SB	13	43.25
									SD	43	86.00
									ST		
									TP	40	70.50
									UT	10	13.00
									ZS		
									OR	47	73.75
	2	1.00					22	56.00		279	541.00

TOTAL IRREGULAR HOURS - 57.00 TOTAL REGULAR HOURS - (W/O ABNORMAL) 541.00 % OF IRREGULAR HOURS - 10.54%

Appendix F-5

Paint Department Abnormal Condition Detail Report

CONTRACT # HULL #
HOURS CHARGED TO W.O. #

COMPARTMENT	DATE	ABN. COND. CODE	HOURS	LEADMAN CLK. #	COMMENTS
	8/18/89	OR	.75		TRAVEL TIME
	8/17/89	OR	.75		TRAVEL TIME
	8/16/89	OR	.50		TRAVEL TIME
	8/15/89	OR	.50		TRAVEL TIME
	8/14/89	OR	.75		TRAVEL TIME
	8/11/89	OR	.50		TRAVEL TIME
	8/11/89	OR	1.75		PICK-UP EQPT & PNT & TRVL TIME
	8/10/89	OR	.50		TRAVEL TIME
	8/10/89	TR	.50		MOVE TOOLS
	8/09/89	OR	.50		TRAVEL TIME
	8/09/89	TR	1.00		RMV TOOLS-IN WAY
	8/08/89	OR	.50		TRAVEL TIME
	8/07/89	OR	8.50		TRVL TIME-PLNT II,2 MEN,8/4/89
	8/04/89	OR	1.00		TRAVEL TIME
	8/03/89	OR	4.00		APPLIED WRONG COLOR
	7/27/89	OR	4.50		LAYOUT WATERLINE
	7/21/89	OR	4.00		NO VENT OVERSPRAY
	7/19/89	OR	5.00		SD-NO VENT FOR SPRAYING
	7/18/89	OR	6.00		NO VENT FOR SPRYNG (SANDING)
	7/17/89	OR	9.00		COVER EQUIPMENT IN SHOP
	7/16/89	WT	4.00		WATER DECK/MOISTURE IN HOSES
	7/02/89	FE	1.50		AIRLESS MALFUNCTION
COMPARTMENT TOTAL			56.00		
FINAL TOTAL			56.00		

Appendix F-6

Paint Department Percent Completion Report

REPORT RUN DATE - 9/14/89

PAINT DEPARTMENT PERCENT COMPLETION REPORT

CONTRACT: HULL:

W.O. #	W.O. DESCRIPTION	BUDGET HOURS	CURRENT ESTIMATE	REWORK HOURS	LOST TIME HOURS	REGULAR HOURS	YTD HOURS	HOURS LEFT WRT CURRENT EST	% COMPL WRT BUDGET (CALC)	% COMPL WRT CURRENT ESTIMATE (CALC)	% COMPL WRT PHYSICAL PROGRESS
	PNT. TANKS	156.00	159.00	8.00		150.25	158.25		101%	100%	*CLOSED*
	TOUCH UP PAINT	3534.00	4095.00			76.50	76.50	4018.50	2%	2%	
	EXT 1RST HULL 01DKDN	2010.00	2000.00	195.50		1746.00	1941.50	58.50	97%	97%	
	EXT 1RST HULL 01DKUP	730.00	730.00	20.00		702.75	722.75	7.25	99%	99%	
	EXT HULL/FIN 01DCKDN	2191.00	2991.00					2991.00	%	%	
	EXT SPRSTR/FIN MN&UP	2884.00	2648.00					2648.00	%	%	
	PNT. FRAMES	195.00	352.00			352.25	352.25		181%	100%	*CLOSED*
	NONSKID WEA DK/01	116.00	116.00					116.00	%	%	
	NONSKID WEA DK/02	64.00	64.00					64.00	%	%	
	NONSKID WEA DK/03	72.00	72.00			34.00	34.00	38.00	47%	47%	
	NONSKID WEA DK/AFT MN	116.00	116.00					116.00	%	%	
	NONSKID MAST	24.00	24.00						%	%	*CLOSED*
	PAINT FURNITURE	1449.00	1449.00	.75		1001.50	1002.25	446.75	69%	69%	
	PRC. WEA DK/01	1133.00	1129.00	1.00	2.00	558.75	561.75	567.25	50%	50%	
	PRC. WEA DK/02	629.00	623.00			307.75	307.75	315.25	49%	49%	
	PRC. WEA DK/03	471.00	467.00	2.00		214.50	216.50	250.50	46%	46%	
	PRC. WEA DK/AFT MN	567.00	565.00			298.25	298.25	266.75	53%	53%	
	PRC. CHAIN LCKR VOID	6.00	26.00			25.50	25.50		425%	98%	*CLOSED*
	PRC. BLOCKING	312.00	312.00			173.00	173.00	139.00	55%	55%	
	PRC VOIDS	51.00	62.00			62.00	62.00		122%	100%	*CLOSED*
	S/B & PNT MISC PARTS	80.00	94.00			93.50	93.50		117%	99%	*CLOSED*
	S/B & PNT MISC PARTS	282.00	21.00	.50		20.00	20.50		7%	98%	*CLOSED*
	S/B & PNT MISC PARTS	6080.00	6000.00	4.75		5809.00	5813.75	186.25	96%	97%	
	S\B & PNT SHAFTS P&S	4.00	7.00			6.50	6.50		163%	93%	*CLOSED*
	TREAT WOOD SHELVING	295.00	295.00			179.00	179.00	116.00	61%	61%	
	PAINT HAND RAILS	300.00	300.00			306.50	306.50		102%	102%	*CLOSED*
	PRM/1STFIN HLD FR1-41	261.00	263.00	1.00		160.75	161.75	101.25	62%	62%	
	PRIME 1ST FINISH AMR	709.00	679.00			453.75	453.75	225.25	64%	67%	
	PRIME 1ST FINISH MMR	1037.00	1007.00	9.00		441.75	450.75	556.25	43%	45%	
	PRM HOLD DK FR 86-120	127.00	127.00			103.00	103.00	24.00	81%	81%	
	PRM 1ST FN PT DK 1-41	555.00	550.00	7.00	1.00	538.75	546.75	3.25	99%	99%	
	PRM 1ST FN PLT 86-120	698.00	700.00			676.75	676.75	23.25	97%	97%	
	PRM 1ST FN MN DK 1-28	700.00	750.00			719.50	719.50	30.50	103%	96%	
	PRM 1ST FN MN D 28-41	362.00	363.00	8.50		341.00	349.50	13.50	97%	96%	
	PRM/1ST FIN MN 41-75	369.00	366.00	7.00		273.00	280.00	86.00	76%	77%	
	PRIM 1ST FIN 01 28-52	335.00	334.00	5.00		277.25	282.25	51.75	84%	85%	
	PRIM 1ST FIN 01 52-86	500.00	500.00	19.25		465.00	484.25	15.75	97%	97%	
	PRIM 1ST FIN 02 28-63	652.00	700.00	12.50		673.75	686.25	13.75	105%	98%	
	PRIME 1ST FIN UPTAKES	204.00	204.00			63.00	63.00	141.00	31%	31%	
	PAINT MAST AND STACK	347.00	294.00	2.00		234.75	236.75	57.25	68%	81%	
	FINISH 2- 0- 0-A	86.00	44.00					44.00	%	%	
	FINISH 2- 14- 0-L	75.00	75.00					75.00	%	%	
	FINISH 2- 18- 2-L	31.00	31.00					31.00	%	%	
	FINISH 2- 23- 0-Q	31.00	31.00					31.00	%	%	
	FINISH 2- 23- 2-Q	56.00	56.00					56.00	%	%	
	FINISH 2- 28- 0-L	87.00	87.00					87.00	%	%	

REPORT RUN DATE - 9/14/89 PAINT DEPARTMENT PERCENT COMPLETION REPORT

CONTRACT: HULL:

W.O. #	W.O. DESCRIPTION	BUDGET HOURS	CURRENT ESTIMATE	REWORK HOURS	LOST TIME HOURS	REGULAR HOURS	YTD HOURS	HOURS LEFT WRT CURRENT EST	% COMPL WRT BUDGET (CALC)	% COMPL WRT CURRENT ESTIMATE (CALC)	% COMPL WRT PHYSICAL PROGRESS
CONTRACT TOTALS		42534.00	43705.00	390.75	6.00	18222.75	18619.50	25065.50	44%	43%	
OPENED W.O. TOTALS		24962.00	25485.00	382.25	6.00	17203.25	17591.50	7893.50			
CLOSED W.O. TOTALS		1127.00	1048.00	8.50		1019.50	1028.00				
NOT OPENED W.O. TOTALS		16445.00	17172.00					17172.00			

Appendix G

Hotwork Checklist for a Small Vessel

On the following checklists, the location is defined as the stiffener count from the Center Line to the Starboard or Port side, Frame Number, and low to high. The comment column states whether the item was found or if a discrepancy exists between Hull 1 and Hull 2.

PANEL DESCRIPTION : AFT BHD FR6
DRAWING NUMBER: DVB1025

HOTWORK DESCRIPTION	LOCATION CL	HT	QTY	COMMENT
REINFRCMT PLATE	P1	0	1	
REINFRCMT PLATE	P2	0	2	
HRZTL PLATE	P2	1	4	
REINFRCMT PLATE	P2	1	1	NOT FOUND
HRZTL PLATE	P2	2	4	
BAR	P2	3	2	
HRZTL PLATE	P2	3	2	
BAR	P2	5	1	
MCT PNTRTN	P3	1	1	
HYD PNTRTN	P3	2	2	
BRACE TO PORT SIDE	P3	3	1	
BRACE TO PORT SIDE	P3	4	1	
TST FTG PNTRTN	P3	4	1	
REINFRCMT PLATE	S1	0	1	
HRZTL PLATE	S1	1	4	
HRZTL PLATE	S1	2	4	
BAR	S1	3	1	
HRZTL PLATE	S1	3	2	
BAR	S1	4	1	
BAR	S1	5	1	
REINFRCMT PLATE	S2	0	1	
REINFRCMT PLATE	S2	1	1	
REINFRCMT PLATE	S3	0	1	
BAR STOCK	S4	2	1	
BRACE TO STBD SIDE	S4	3	1	
HVY REINFORCEMENT	S4	3	PNL	LNGTH
MCT PNTRTN	S4	3	1	
BRACE TO STBD SIDE	S4	5	1	

PANEL DESCRIPTION: FWD BHD FR6
DRAWING NUMBER: DVB1025

HOTWORK DESCRIPTION	LOCATION CL	HT	QTY	COMMENT
BAR	P1	1	1	NOT FOUND
BAR	P1	3	1	NOT FOUND
BENT PLATE	P2	1	1	ON 2, NOT ON 1
FLAT PLATE	P2	1	1	ON 2, NOT ON 1
PIPE CLAMP	P2	1	2	ON 2, NOT ON 1
ANGLE BAR	P2	2	1	
BAR	P2	2	1	
PIPE CLAMP	P2	2	1	
REINFRCD CURVATURE	P2	2	1	
BENT CLAMP	P2	3	1	ON 2, NOT ON 1
PIPE CLAMP	P2	3	2	NOT FOUND
PIPE CLAMP	P2	4	1	3 FOUND, incl 2 FROM P2-3
MCT PNTRTN	P3	1	1	
PIPE CLAMP	P3	1	1	ON 2, NOT ON 1
ANGLE IRON	P3	2	1	
HYD PNTRTN	P3	2	2	
PIPE CLAMP	P3	2	1	ON 2, NOT ON 1
PIPE HNGR	P3	3	2	
PIPE HNGR	P3	4	2	
TST FTG PNTRTN	P3	4	1	
PIPE CLAMP	P3	3	1	ON 2, NOT ON 1
SMALL PLATE	S1	4	1	ON 2, NOT ON 1
SMALL PLATE	S2	4	1	ON 2, NOT ON 1
MCT PNTRTN	S4	3	1	
STUD	S4	3	1	

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The University of Michigan
Transportation Research Institute
Marine Systems Division
2901 Baxter Rd.
Ann Arbor, MI 48109-2150
Phone: (313) 763-2465
Fax: (313) 936-1081